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Sporadic nesting events of loggerhead sea turtles *Caretta caretta* along the Greek coasts of the Ionian Sea

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Abstract

Sporadic nesting events (i.e., any evidence of nesting or attempted nesting) of loggerhead sea turtles *Caretta caretta*, outside of the systematically monitored nesting areas, were recorded over 40 years (1985–2024) in the Ionian Sea, Greece. Most nesting events were reported by the public. Accumulated records show a wide distribution of nesting events along the coasts, without a considerable north–south gradient—contrasting with a similar study in the Aegean Sea, where nesting was rather uncommon in northern latitudes. This discrepancy is attributed to the different temperature regimes between the two marine areas. Beaches with frequently reported nesting events should be surveyed systematically to assess their nesting magnitude. The consequences of a possible northward expansion of loggerhead nesting in the Ionian are discussed.

Key Words

citizen science, climate change, colonization, expansion of breeding range, nesting areas, nesting distribution

The loggerhead sea turtle, *Caretta caretta*, is a cosmopolitan species breeding in warm temperate and subtropical regions and rarely in the tropical zone (Dodd 1988). In the Mediterranean, loggerheads nest primarily in the eastern basin, with major nesting grounds in Greece, Turkey, and Cyprus (Casale et al. 2018). In Greece, the main nesting areas are located in the Ionian Sea, with two rookeries—those of Kyparissia Bay and Zakynthos—being the largest in the Mediterranean (Casale et al. 2018). ARCHELON monitors most of the important known nesting areas in Greece with long-term programs conducted annually with the help of trained volunteers. These monitoring programs have assisted in the establishment of site-specific protection of breeding areas through national legislation and European Commission (EC) programs (e.g., the NATURA 2K network of protected areas) (Dimopoulos et al. 2003).

Besides monitoring the main rookeries, ARCHELON collects data on sporadic nesting, i.e., nesting events outside the monitored areas. We consider "nesting event" any of the following: (1) live adult sea turtles or hatchlings on the beach, (2) tracks of sea turtles (of adults or hatchlings) imprinted on the sand, or (3) sea turtle eggs or eggshells on the beach. Sporadic nesting events were initially reported by members and friends of ARCHELON, with related data collected in a paper file. Later on, with growing public awareness of sea turtle conservation, citizens started to report nesting events through ARCHELON phone numbers, usually via the 7 d–24 h telephone line at ARCHELON's Sea Turtle Rescue Centre in Glyfada, Attica. Since 2024, reporting of nesting events has been upgraded through an electronic platform (in Greek and English) on ARCHELON's website (https://archelon.gr/en/support-us/found-a-nest-or-hatchlings).

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In the early years, the location of a nesting event was archived by the beach's name and the corresponding municipality or the name of a nearby village or town. In some cases, more specific information (e.g., distance from a nearby conspicuous landmark) was provided. In recent years, GPS coordinates started to appear in citizens' reports, which were augmented with the instigation of the electronic platform in 2024.

Citizens were asked to supply photographs of the nesting event, and in cases where a clutch of eggs may have been laid, they were encouraged to protect the nest site with any available appropriate material—usually bamboo sticks and red tape—to avoid trampling. We did not encourage validation of a possible nest, e.g., by excavating the sand to confirm the existence of eggs, as this could disrupt the clutch's incubation. Occasionally, in cases of bright light sources close to a possible nest, citizens constructed makeshift shadings around the nest site against hatchling disorientation. Nest protection efforts were usually assisted by the local Coast Guard or municipality.

We scrutinized all collected reports from the 40-year period (1985–2024) to avoid duplication of the same event by checking the exact location, wherever possible, and the date of the event. In addition, we excluded reports of hatchlings or hatchling tracks after 45–60 days from a previously registered nest at the same location. Nesting events reported from regularly monitored areas were not considered.

In the 40-year period, we recorded a total of 583 nesting events along the Greek shores of the Ionian Sea (Fig. 1). Of note, some areas concentrated nesting events repeatedly over the years, and this deserves further examination. All photographed adult turtles and hatchlings were identified as loggerhead sea turtles.

Reported records contained all criteria for defining a nesting event, i.e., emergence tracks, live turtles, or exposed eggs (Fig. 2). Exposed eggs were a result of nest predation (Fig. 2C) or beach erosion (Fig. 2D). Nest predation—primarily by foxes and secondarily by stray dogs and jackals—is common on mainland Greece and the Peloponnese (Margaritoulis and Panagopoulou 2010).

Despite the opportunistic nature of data acquisition, we consider that the accumulated nesting events over four decades portray a realistic picture of the spatial distribution of sporadic nestings along the Greek shores of the Ionian Sea.

A similar study in the Aegean Sea revealed that nesting events in latitudes higher than 39°N are rather unusual (Margaritoulis et al. 2025). This does not seem to be the case in the Ionian Sea, where nesting events are not uncommon above 39°N, i.e., north of Amvrakikos Gulf (Fig. 1). Further, loggerhead turtles are known to nest to the north, in the Adriatic Sea, as reported from Albania (Piroli and Haxhiu 2020) and Italy (Mancino et al. 2022). The difference in the reported nesting latitudes between the Aegean Sea and the Ionian Sea is likely caused by the different temperature regimes between the two seas, with the Ionian Sea being warmer than the Aegean Sea (Pastor et al. 2018).

A remarkable nesting event, reported in 2024, was recorded within Amvrakikos Gulf (Fig. 1)—a well-documented developmental and foraging habitat of loggerhead turtles (Rees et al. 2013)—where breeding of loggerheads was not previously known. Furthermore, three unusual nesting events were reported at the eastern part of the Gulf of Corinth (Fig. 1).

Improvised nest protection (Fig. 3) was generally effective, as many of the protected nests produced hatchlings. Following instructions by ARCHELON, several citizens residing close to protected nests maintained watch for any hatchling emergence. Long-standing public awareness programs by ARCHELON and other environmental entities have, over the years, increased citizens' sensitization to sea turtle conservation.

Loggerheads are noted for their relatively low nest site fidelity; hence, they may nest opportunistically on beaches other than their natal beach, and if they find suitable conditions, they may colonize new areas (Carreras et al. 2018). The regional distribution of sporadic nesting has broadened in recent years, due to global warming, to the extent that today it is widely recognized that the loggerheads' traditional breeding range in the Mediterranean has expanded—both westwards (Hochscheid et al. 2022) and northwards (Bentivegna et al. 2010). If the newly nested beaches are also suitable for egg incubation, providing adequate hatching success and appropriate hatchling sex ratio, they may become new habitats of regular nesting (Hochscheid et al. 2022). Therefore, in this context, evaluating the magnitude of sporadic nesting is of increasing importance, as it may disclose new areas of potential regular nesting, as has been seen in Calabria (Mingozzi et al. 2007) and in Sicily (Prato et al. 2022). The implementation of systematic beach surveys for a number of nesting seasons may then be applied to priority sites in order to acquire meaningful and rigorous nesting assessments.

In an attempt to investigate the temporal distribution of nesting events across latitude, we positioned all citizen reports in 5-year bins south and north of 39°N. Our diagram showed clearly that northern events have increased in recent years (Fig. 4).

However, we cannot be certain that this represents an actual northward expansion of loggerhead nesting. Reporting of a nesting event is likely also influenced by a combination of increased citizens' sensitization and increasingly easy communication—such as the promotion of social media and messaging platforms, enabling images to be instantly shared among citizens—which augments the likelihood of records reaching our recording platforms, as well as the increasing ease of human transportation and access to the coast. The fact that the Mediterranean loggerhead turtle population has undergone significant recovery in recent decades (Casale et al. 2018) will likely also have contributed to the increased frequency of sporadic nesting events across the study area. All the above factors could have enhanced reporting, especially in northern latitudes, where sea turtle nesting was, until recently, rather uncommon in relation to southern latitudes. Whatever the reason, these nests—despite makeshift efforts to protect them—remain without

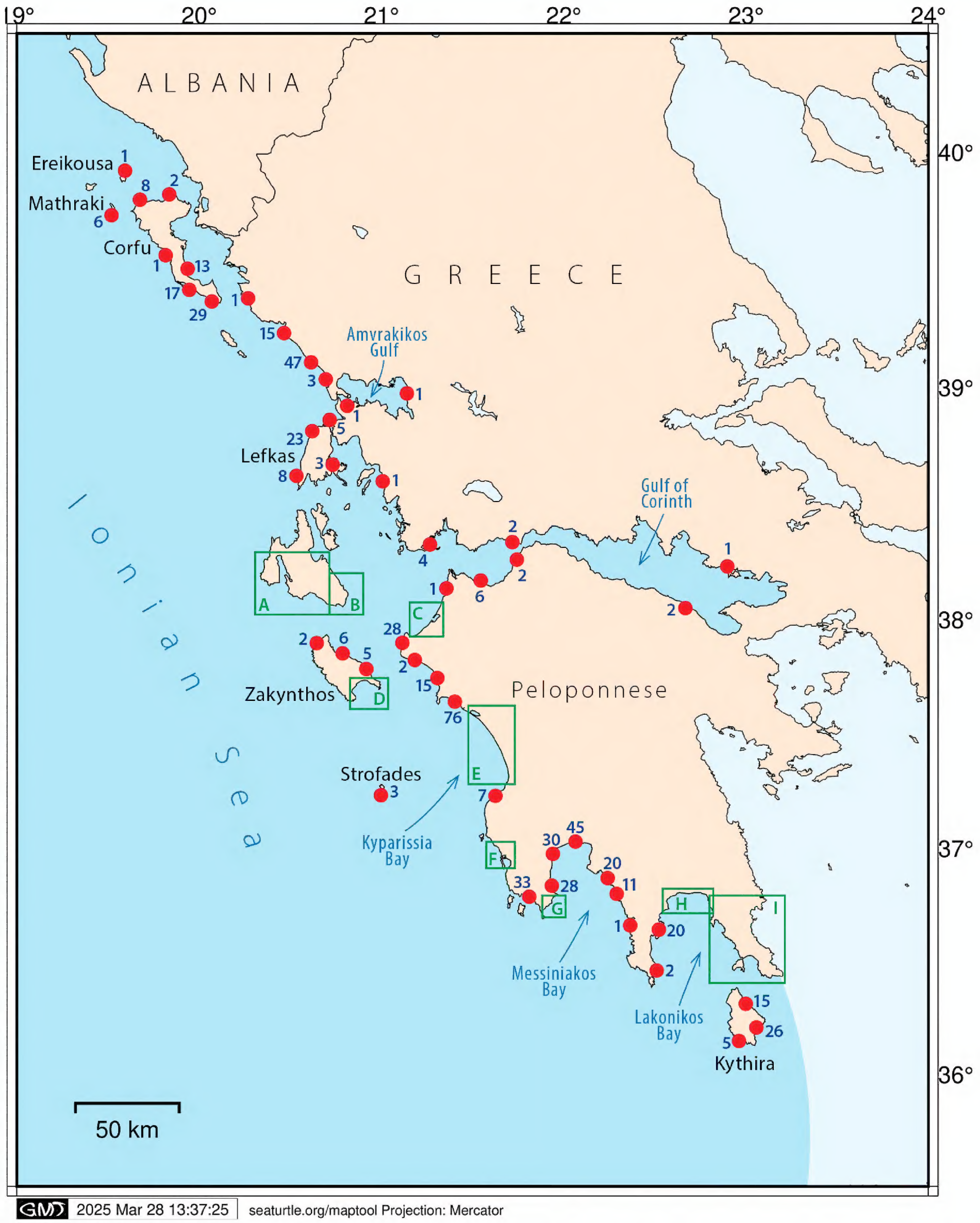

Figure 1. Records of sporadic nesting events along the Greek coasts of the Ionian Sea (darker blue area), collected over 40 years (1985–2024). Records (red dots) are clustered per municipality or by proximity. Dark blue numbers show records per cluster. Green rectangles indicate areas of regular nesting, monitored annually by ARCHELON and other organizations.

proper protection, and several of these nests may not successfully incubate through to hatching. The loggerhead nesting season in Greece coincides with the high tourist season (June–September). Indeed, many beaches along the Epirus coast and Corfu Island feature today increased tourism and coastal developments, which do not favor the turtles' breeding. The prevalent beach furniture, bright lights, mechanized beach cleaning, and speedboats are

Figure 2. Examples of nesting events, photographed by citizens. **A.** Tracks of adult turtle (Katakolo, 6 July 2024); **B.** Emergent turtle (Kalamata, 7 June 2024); **C.** Predated nest (Kyllini, 18 August 2023); **D.** Exposed eggs due to beach erosion (Lampes Methonis, 5 August 2021); **E.** Hatchling tracks indicating a hatched nest (Mpouka Messinis, 14 August 2018); **F.** Hatchling heading to the sea (Corfu, 9 August 2022).

well-documented factors threatening sea turtle nesting (Margaritoulis and Panagopoulou 2010).

It is questionable, therefore, whether a hypothesized northward expansion of loggerhead nesting will be successful in Greece, as several beaches identified with relatively high numbers of sporadic nesting are becoming highly touristic. The colonizing loggerheads nesting in the western Mediterranean are already facing such threats, as beaches that traditionally held no turtle nesting and were urbanized or developed for tourism now host nests that are imperiled by anthropogenic influences (Hochscheid et al. 2022). Consequently, loggerheads that are forced by global warming to accomplish their nestings on northern beaches may end up in some form of an "ecological trap," as recounted by Pike (2013).

Although it is generally not known whether nesting range expansions are undertaken by new recruits or old nesters, it might be ironic if loggerheads currently nesting successfully in the protected areas of Zakynthos and Kyparissia Bay were driven northwards by increased temperatures—which may render their current nesting sites unsuitable—and attempted to nest in Epirus and Corfu, amid a plethora of uncontrolled pressures. It took many years of unswerving efforts by NGOs and supranational entities to induce governments to establish these protected areas, and it seems challenging to reiterate anew similar efforts for other areas. However, there is room for action if needed—either by encouraging bottom-up measures, implemented voluntarily by coastal enterprises and other stakeholders, or through top-down administrative measures. Such measures would include stacking loungers at night, dimming bright lights, and protecting laid nests either *in situ* or through relocation. There is vast experience in such tested protective actions from ARCHELON's long-standing programs implemented so far. Although it may still be a long way to

Figure 3. Nests protected *in situ* by citizens. **A.** Kastrosykia, Epirus (20 June 2022); **B.** Valtos Beach, Parga (27 May 2018); **C.** Agia Pelagia, Kythira (20 July 2023); the shading is to protect emerged hatchlings from disorientation because of a nearby artificial light source.

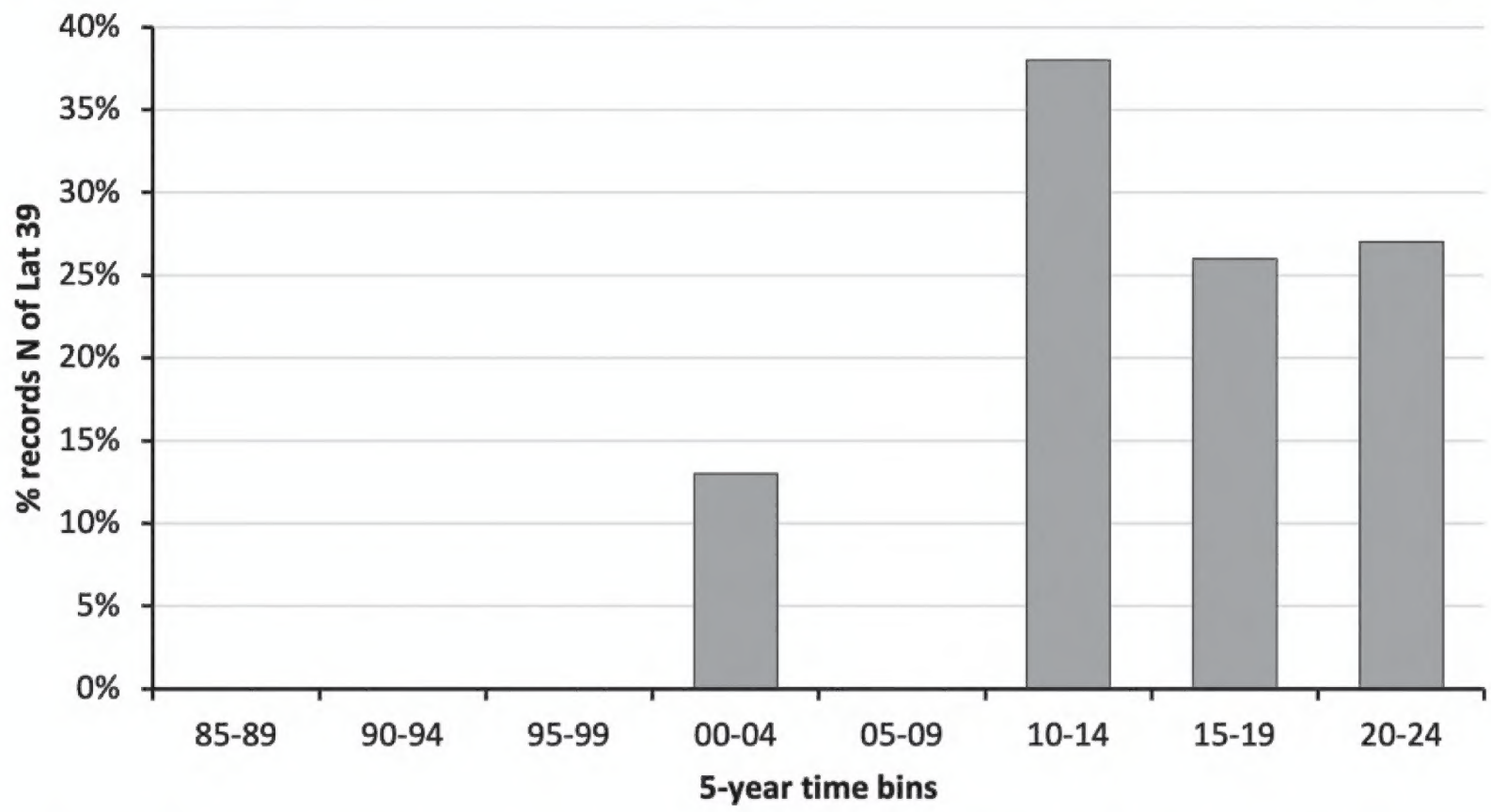

Figure 4. Percentage of total reported nesting events north of 39°N, in 5-year bins, over the 40-year study period (1985–2024).

go before colonizing loggerheads instigate new nesting areas, we should remain vigilant and frequently inspect the most suitable of those beaches.

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